Polar Surface Anchoring of a Tilted Nematic Liquid Crystal and the Dual Easy Axis Model

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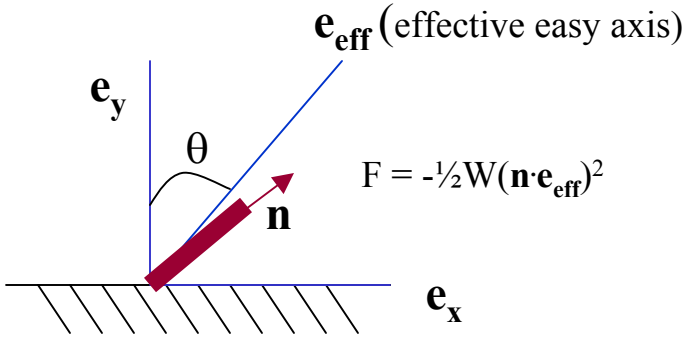
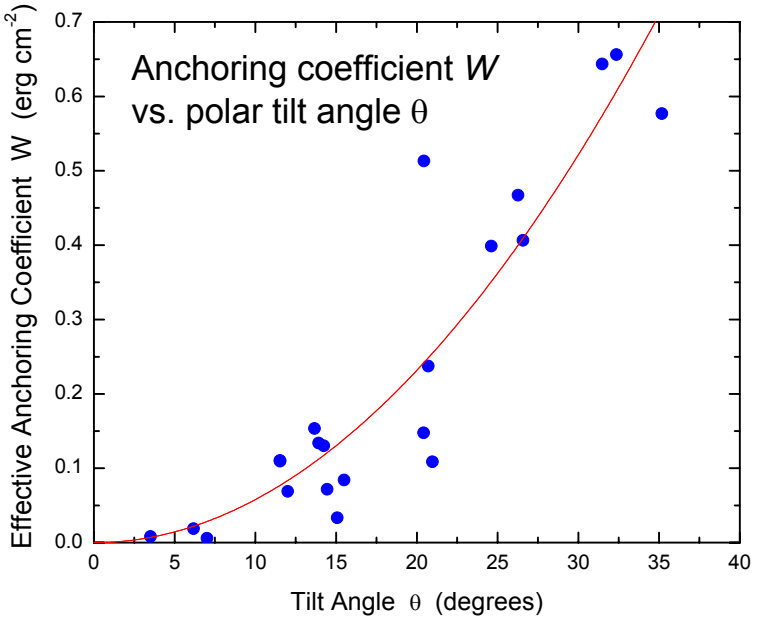
Liquid crystals tend to align at an interface parallel to an effective "easy axis" $\mathbf{e}_{\mathbf{eff}}$. Deviations from $\mathbf{e}_{\mathbf{eff}}$ of the LC orientation $\mathbf{n}$ entail an energy cost $F = -\frac{1}{2}W(\mathbf{n}\cdot\mathbf{e}_{\mathbf{eff}})^2$. We have discovered a technique to create an easy axis $\mathbf{e}_{\mathbf{eff}}$ that is *tilted* with respect to the substrate. The data represent the first measurement of $W(\theta)$ when the equilibrium orientation is *not* $\theta = 0$ or 90^o. Two important conclusions:



1. W vanishes as $\theta \rightarrow 0$

2. That $W \propto \theta^2$ is the first proof that the *effective* easy axis $\mathbf{e}_{\mathbf{eff}}$ actually is the equilibrium orientation for a *pair* of easy axes, one $\parallel$ ($\mathbf{e}_x$) and one $\perp$ ($\mathbf{e}_y$) to the interface.

This work will provide new methods for designing and electrically addressing LCDs and variable retarders.



Broader Impact

- Spin-off research agreement signed with Nissan Chemical Industries, Ltd.
- Involvement of 1 postdoc and 2 grad students (one female)

The traditional alignment orientation of liquid crystals is either vertical or planar with respect to a substrate. We have discovered that an overbaked polyamic acid designed for vertical alignment that is subsequently rubbed will give rise to a tilted orientation with respect to the substrate normal. For the first time we have measured the anchoring strength coefficient for the liquid crystal 5CB as a function of its equilibrium orientation direction. We found that the polar anchoring strength is proportional to the square of the equilibrium tilt angle. Until now it was assumed that a tilted director orientation requires a single, but tilted, "easy axis." The fact that the tilt angle vanishes as theta approaches zero proves that this picture is not correct. Rather, the data show that there exists a *pair* of easy axes, one approximately vertical and one approximately planar, with the liquid crystal's equilibrium orientation determined by a tradeoff between the two easy axes. In addition to the fundamental importance of understanding liquid crystal interactions with a substrate — indeed, these results force a significant modification of the standard single easy axis picture — the results hold technological promise for tailoring display devices by controlling the tilt and its response to an applied electric field.

This work was performed by Dr. Giovanni Carbone and Prof. Charles Rosenblatt at Case Western Reserve University during the summer, 2004. It is being prepared for publication. Based on our work with this polyimide, we have signed a research agreement with Nissan Chemical Industries, Ltd. Currently Dr. Carbone plus two new graduate students (one female) are working on experiments related to this phenomenon.